Evaluation of a Tactical Surface Metering Tool for Charlotte Douglas International Airport via Human-in-the-Loop Simulation

DASC
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Outline

• Background
  – The Challenge
  – Previous Research
  – ATD-2’s Metering Tool
• Objectives of Study
• Tactical Surface Metering Tool
• Experiment Details
• Results
• Summary
The Challenge

Surface Congestion

Loss of Predictability

Long Runway Queue

Will Departure/Surface Metering help?
Previous Research on Metering Tool

• Strategic Metering Tool at JFK (Stroiney et. al. 2013)
  – Schedules provided two hours in advance
  – Taxi out benefits ranged from 1.5 to 2.7 min per flight

• Spot and Runway Departure Advisor (SARDA) (Jung, Malik, Gupta & Hayashi, 2014)
  – Tactical in nature, schedules for the next 15 min
  – Benefits to taxi times were shown for both DFW and CLT
  – SARDA did not use ready times or Earliest Off Block Times (EOBT) or Ration By Schedule (RBS) principles for creating schedules

Need a tactical metering tool that can be extended to include strategic scheduling
ATD-2’s Metering Tool

• Does not control capacity, just estimates it
• Provides advisories that throttle demand to the runway during surface metering
  – Earliest off block times are used to estimate demand at any given time.
  – The tool does not double delay flights subject to FAA restrictions
  – Orders flights based on their accuracy of EOBTs, Priority, FAA restrictions, exempted flights
• Provides pushback advisories based on calculated Target Off Block Times (TOBT)

ATD-2 = Airspace Technology Demonstration-2
Objective of the Study

- Evaluate the Metering tool that provides recommended gate hold times or pushback advisories based on the formula:
  \[ TOBT = \max [EOBT, TTOT - UTT - \text{Metering Value}] \]

- Evaluate the Metering Value that is agreeable to both Airline Ramp and the ATC-Tower
  - Metering value is a buffer or excess queue time that could be taken at the gate or as taxi delay

EOBT = Earliest Off Block Time
TOBT = Target Off Block Time
TTOT = Target Take Off Time
UTT = Unobstructed Taxi Time
Tactical Surface Metering Concept

Gate Pushback Advisories

Data Exchange & Integration

Efficient Runway Schedule

Spot Release Advisories

Surveillance

EOBT

Arrival Demand

ATC Intent

Surface Modeler

Runway Scheduler

Spot Advisor

Gate Advisor

Unobstructed Runway Times

Runway Times

Metered Spot Times

Metered Pushback Times

EOBT – Earliest OFF Block Times,  RBS= Ration By Schedule

Metering Tool
Metering Tool Advisories on User Interface

- **Push advisory**
  
  ![Push advisory image]

  EOSB < 10 min

- **Gate Hold Advisory**
  
  ![Gate hold advisory image]

  EOSB < 10 min

- **Hashtag: Click here to get an advisory**
  
  ![Hashtag image]

  EOSB > 10 min
Experiment Details

- Experimental Matrix
- Scenario
- Participants
- Tools and Equipment
Experiment Matrix

- Two variables:
  - Metering Value / Level of Hold (3 levels)
  - Airport Configuration (2 levels)
  - 3 x 2 matrix

<table>
<thead>
<tr>
<th>Metering Value</th>
<th>Runway Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North</td>
</tr>
<tr>
<td>8 min</td>
<td>N_8</td>
</tr>
<tr>
<td>10 min</td>
<td>N_10</td>
</tr>
<tr>
<td>12 min</td>
<td>N_12</td>
</tr>
</tbody>
</table>
Airport Map - Charlotte Douglas International
Traffic Scenario in CLT

- South Dual Converging Operation
  - 92 arrivals & 80 departure per hour
- Triple North Operation
  - 75 arrivals & 65 departures per hour
- No wind, clear visibility, but IFR rules in effect
- No General Aviation flights
- No Cargo flights
- Duration 60 min
Participants

- Four Ramp Controllers – two active and two retired controllers
- One Ramp Manager
- Five Pseudo pilots as confederates
Tools & Equipment

- Ramp Control Tower to emulate Charlotte
  - 360 degree Simulator at Future Flight Central (FFC)
  - Ramp Traffic Console (RTC) & Ramp Manager Traffic Console (RMTC)
Ramp Traffic Console
Results

• Gate Hold Time
• Acceptability of Gate Hold Times
• Taxi Out Time
• Taxi In Time
• Queue in Airport Movement Area
• Run Durations
• Workload
• Situational Awareness
• Acceptability of departure queue
• Acceptability of departure demand
Gate Hold Time

- South Flow Gate holds decrease as metering value increases
- North Flow is possibly impacted by short run duration
- Compliance to gate hold times is within 1 min
Acceptability of Gate Hold Times

Gate hold times were reported as “just right” by the participants

Results
Queue in Movement Area

North Flow Queue in Movement Area

South Flow Queue in Movement Area

- South Flow responds to different Metering values
- North Flow is not as responsive
## Run Duration

<table>
<thead>
<tr>
<th>Run name</th>
<th>Runway Configuration</th>
<th>Metering value (min)</th>
<th>Run duration (min)</th>
<th>Departure number (OFF)</th>
<th>Arrival number (IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N_8</td>
<td>North flow</td>
<td>8</td>
<td>66.3</td>
<td>44</td>
<td>38</td>
</tr>
<tr>
<td>N_10</td>
<td></td>
<td>10</td>
<td>50.2</td>
<td>27</td>
<td>26</td>
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<tr>
<td>N_12</td>
<td></td>
<td>12</td>
<td>67.2</td>
<td>54</td>
<td>50</td>
</tr>
<tr>
<td>S_8</td>
<td>South flow</td>
<td>8</td>
<td>53.4</td>
<td>42</td>
<td>28</td>
</tr>
<tr>
<td>S_10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S_12</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Gate Hold and Taxi Time increases with increase in run duration more so in North Flow than South Flow

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### Results

![Graph showing gate hold and taxi-out time against run duration](image-url)

- **GateholdT, North**: Blue diamonds
- **GateholdT, South**: Red circles
- **Taxi-outT, North**: Blue diamonds
- **Taxi-outT, South**: Red circles

**Graph Details**

- **X-axis**: Run duration (min)
- **Y-axis**: Gate hold or taxi-out time (min)
Workload was not significantly impacted by changes in the metering value.
The departure demand was reported as acceptable by both Ramp and ATC-T for metering value of 12
Summary

- Metering value affects Gate Hold Time and Queue Size as expected
- Gate Hold Times were reported as "just right"
- Metering value of 12 reported as not drying up the runway or seen as creating long queues
- Metering value of 12 planned to be used as the nominal value for metering tool when deployed in the field
Thanks for your attention!

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Throughput in North

Accumulated takeoffs - North flow

- N_8
- N_10
- N_12
Throughput in South

Accumulated takeoffs - South flow

Simulation time (minute)

Takeoffs (ac)

S_8
S_10
S_12
Setting Metering Value

Level of Holds is based on Metering Value and is a balance between gate holds and runway queue size
Tactical Surface Metering Concept

- Estimates capacity of current and future runway resources
- Builds an efficient runway schedule based on readiness, EOBT and RBS
- Calculates spot advisories that support the metered runway schedule
- Provides push back advisories from gates that support the spot advisories

![Diagram showing the process of tactical surface metering concept]

- Surface Modeler
  - Unobstructed Runway Times
- Runway Scheduler
  - Runway Times
- Spot Advisor
  - Metered Spot Times
- Gate Advisor
  - Metered Pushback Times

EOBT – Earliest OFF Block Times, RBS= Ration By Schedule
ATD-2’s Metering Tool

Data Exchange & Integration
- Integrated Arrival/Departure/Surface (IADS)
- Onramp to the overhead stream
- New data elements shared between FAA & Industry
- Real-time metrics for planning and awareness

Surface modeling, scheduling & metering
- Surface modeling based on heuristics and trajectory based model of airport operations
- Use of Earliest Off Block Times (EOBT) for the purpose of Scheduling
- Surface Metering based on demand and capacity imbalances, tactical in nature initially
### EOBT Groups Metering Tool

<table>
<thead>
<tr>
<th>Group</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uncertain</strong></td>
<td>Flights with poor quality EOBT OR EOBT – current time &gt; 10 min</td>
</tr>
<tr>
<td><strong>Planning</strong></td>
<td>Flights within 10 min of EOBT (i.e., EOBT – current time &lt;= 10 min)</td>
</tr>
<tr>
<td><strong>Ready</strong></td>
<td>Flights that have called in ready for pushback</td>
</tr>
<tr>
<td><strong>Out</strong></td>
<td>Flights that are in pushback state</td>
</tr>
<tr>
<td><strong>Taxi</strong></td>
<td>Flights that are cleared for taxi</td>
</tr>
<tr>
<td><strong>Queue</strong></td>
<td>Flights waiting in the runway queue</td>
</tr>
</tbody>
</table>

**Order of Consideration:**

- Less Predictability → Lower
- More Predictability → Higher

**Predictability:** Less → Lower, More → Higher